XXV. *Experiments on the Length of the Seconds Pendulum at the Royal Observatory of Greenwich. By Captain* EDWARD SABINE, *of the Royal Regiment of Artillery, F.R.S.*

Read June 16, 1831.

THESE experiments were made with the original convertible pendulum constructed by Captain KATER, and employed by him in 1817 in Portland Place, London.

Prior to its employment in the present experiments I made the following alterations in the pendulum.

1. The tail pieces were removed altogether; coincidences being observed by the bar itself (the ends being blackened for the purpose), and by a disc of corresponding diameter on the pendulum of the clock.

2. The "moveable weight" employed by Captain KATER was dispensed with altogether; and the pendulum rendered convertible, within the limits of more exact adjustment by the slider, by filing away a small quantity of metal from one extremity of the bar. By this alteration there remained nothing moveable about the pendulum except the slider; and that was so placed in these experiments, that a change in its position, of so great magnitude as the tenth of an inch, did not occasion an alteration of so much as the tenth of a second in the daily rate of the pendulum, when suspended with the weight below, which is the position in which the rate is determined. The slider was clamped to the bar, and was moved by a screw for slow motion, by which it could be adjusted with tolerable precision to the hundredth of an inch. The graduation on the bar, by which the place of the slider was regulated, was on the side of the bar next the observer, who could thus at all times assure himself that no change occurred in its position by the inversion of the pendulum.

Neither of these alterations interfered with the distance between the knife edges, which was referred in 1817 to Sir GEORGE SHUCKBURGH's scale by Cap-

tain KATER, and found to measure 39.44085 inches of that scale at the temperature of 62°.

The experiments were made, unless where it is otherwise noticed, in the vacuum apparatus, established in the S.W. angle of the pendulum room in the Royal Observatory, being the place assigned for that apparatus by the Astronomer Royal.

The thermometer, by which the temperature of the pendulum was observed, is the same which I have used and described on former occasions; particularly in the Phil. Trans. for 1830, where its comparison is given with a standard thermometer of M. BESSEL'S, at the same temperatures at which it was used in these experiments. In a paper on the construction and use of the vacuum apparatus, in the Phil. Trans. for 1829, I have shown that when the pressure of the air is withdrawn from the exterior of the bulb of this thermometer, an index correction of + 0°.75 is required to make its indications in a highly rarified medium correspond with its measure of the same temperatures when under the pressure of the atmosphere. This index correction is consequently applied whenever the air is withdrawn from the apparatus. The thermometer was inclosed with the pendulum within the glasses, with its bulb suspended midway between the knife edges. When the air is withdrawn from the apparatus, and the shutters of the apartment are kept closed (except when light is required for the observation of coincidences), a great uniformity as well as steadiness of temperature is maintained within the glasses.

Whenever the indications of the barometer were required, a reference was made to the standard barometer of the observatory, which is stationed in an adjoining room on the same level.

The scale by which the arcs of vibration were observed was graduated in degrees, each degree being the 0.833th of an inch. In making the observation, the division of the scale coinciding with one side of the bar was noticed at each extremity of the vibration, and the same repeated with the other side of the bar; a mean was then taken of the two included spaces, and half the mean registered as the arc on either side the vertical. The scale being placed in both positions of the pendulum 45.5 inches below the point of suspension, the registered arcs multiplied by 1.05 produce the true arcs of vibration; by employing these in the usual formula for that purpose, what is usually considered

as the compensation for the arcs is obtained. During the progress of the experiments, however, I had occasion to suspect that, particularly when the pendulum was vibrated with the weight above, the retardation of the vibrations, in consequence of their being performed in circular arcs, was greater than the compensations computed by the customary formula $N \cdot \frac{\sin(A+a).\sin(A-a)}{32\,M.(\log.\sin A - \log.\sin a)}$. To examine this more closely, and to obtain practically a just compensation for the arcs in which the pendulum had been vibrated in the course of its employment, I made several series of experiments distinct from those made to determine the rate, and which I shall proceed to describe in the first instance, though they were not the first in the order of time.

Correction for the Arcs of Vibration.

§ 1. Weight above.

On the 27th of January 1830, I made the following observations, purposing to compare, under circumstances otherwise similar, the rate of the pendulum in different arcs; 1st, commencing with 1°.32 and ending with 0°.73; 2nd, commencing with 0°.70 and ending with 0°.42; and 3rd, commencing with 0°.42 and ending with 0°.19. Having withdrawn the air from the apparatus, the resistance to the vibration was so far diminished, that the time which the pendulum took to reduce its arc from 1°.32 to 0°.73, from 0°.70 to 0°.42, and from 0°.42 to 0°.19, was in each case sufficient to give the rate of the pendulum within the respective arcs with tolerable exactness.

The rate of the clock on this day was taken from its average rate in several days, viz. from the 24th to the 30th of January; exactness in the daily gain or loss of the clock was not required, as the observations were only to be used in their relation to each other.

January 27, 1830. Clock by DENT making 86311.0 Vibrations in a mean solar day.

No. of Coincid.	Therm.	Gauge.	Times of Disapp.	Times of Reapp.	Times of Coincidence.	Arcs of Vibration.	Mean Temp.	Mean Gauge.	Mean Interval.	Reductions to mean tem. 36°.	Reductions to a Vacuum.	Vibrations per diem.
	°	in.	m s	m s	h m s	° °	°	in.				
1	....	....	11 16	11 27	10 11 21.5							
2	34.9	0.86	23 31	23 43	10 23 37	1.26×1.05=1.32	35.1					
3	....	....	35 45	35 59	10 35 52		+ 0.75	1.275	737.90	−0.07	+0.60	86077.59
15	35.3	1.69	3 15	3 44	1 3 29.5	0.70×1.05=0.73	35.85					
	Air pumped out to reduce the gauge.											
							35.35					
16	35.3	0.92	15 35	16 02	1 15 48.5	0.67×1.05=0.70	+ 0.75	1.225	742.53	+0.04	+0.58	86079.14
31	35.4	1.53	21 06	21 47	4 21 26.5	0.40×1.05=0.42	36.10					
							35.45					
31	35.4	1.53	21 06	21 47	4 21 26.5	0.40×1.05=0.42	+ 0.75					
46	....	....	26 37	28 03	7 27 20			1.725	743.41	+0.08	+0.82	86079.66
47	35.5	1.92	38 55	40 26	7 39 40.5	0.18×1.05=0.19	36.20					
48	....	....	51 17	52 48	7 52 02.5							

Examining these observations we have

	I.	II.	III.
Arcs	1.32 to 0.73	0.70 to 0.42	0.42 to 0.19
Vibrations per diem, uncorrected for the arcs	86077.59	86079.14	86079.66
Compensation for the arcs by the formula	+1.67	+0.50	+0.14
These numbers should agree if the corrections for the arcs computed by the formula were a just compensation .	86079.26	86079.64	86079.80

From the differences that are here seen to exist, it appears that when the pendulum is vibrated with the weight above, the compensation for the arcs as computed by the customary formula is in defect; and more in defect as the arcs are larger. To make the results agree, it is necessary to multiply the computed correction by 1.36. By the employment of this multiplier, the result obtained in the arcs of least magnitude (which as being the nearest to infinitely small arcs are presumed to be the most correct,) is not altered more than five-hundredths of a vibration; whilst the results obtained in larger arcs

are brought in accordance with it. The corrections and the corrected vibrations then become

	I.	II.	III.
Corrections for the arcs	+2.27	+0.68	+0.19
	86077.59	86079.14	86079.66
Corrected vibrations	86079.86	86079.82	86079.85

On the 29th January the same process was repeated in arcs differing somewhat from the preceding, and designed therefore to render the differences in the results, should they be found to exist, still more conspicuous.

No. of Coincid.	Therm.	Gauge.	Times of Disapp.	Times of Reapp.	Times of Coincidence.	Arcs.	Mean Temp.	Mean Gauge.	Mean Interval.	Reductions to 36°.	Reductions to a Vacuum.	Vibrations per diem.
	°	in.	m s	m s	h m s	° °	°	in.				
1	34.6	0.80	17 53	18 01	1 17 57	1.39×1.05=1.46	34.55 + 0.75 = 35.30	0.925	737.69	−0.31	+0.42	86077.11
17	34.5	1.05	34 26	34 54	4 34 40	0.76×1.05=0.80						
35	34.4	1.23	17 20	18 04	8 17 42	0.39×1.05=0.41	34.45 + 0.75 = 35.20	1.14	743.44	−0.35	+0.54	86078.98
53	34.1	1.36	0 39	02 04	12 01 21.5	0.17×1.05=0.18	34.25 + 0.75 = 35.00	1.295	745.53	−0.44	+0.61	86079.60

Examining these observations, we have

	I.	II.	III.
Arcs	1.46 to 0.80	0.80 to 0.41	0.41 to 0.18
Vibrations, uncorrected for the arcs	76077.11	76078.98	76079.60
Corrections for the arcs by the formula	+2.03	+0.58	+0.13
Numbers which should agree if the corrections computed by the formula were a just compensation	76079.14	76079.56	76079.73

The inference from this day's experiment is to the same effect as before. The multiplier required in this instance is 1.32, altering the result in the smallest arcs four hundredths of a vibration, and bringing the others in accordance with it. The corrections and the corrected vibrations become

	I.	II.	III.
Corrections	+2.68	+0.77	+0.17
	86077.11	86078.98	86079.60
Corrected vibrations . . .	86079.79	86079.75	86079.77

On February 3rd I made a third series with the pendulum in the same position; the pendulum of the clock had been shortened since January 29th, and was now making about 86371.0 vibrations; but the temperature being at this time very low, its going was less regular than usual. To obviate that inconvenience I commenced with a series in large arcs; made then two series in small arcs, and concluded with a second series in large arcs; and finally took a mean between the two series in large arcs and the two series in small arcs, as the results to be compared with each other.

No. of Coincid.	Therm.	Gauge.	Times of Disapp.	Times of Reapp.	Times of Coincidence.	Arcs.	Mean Temp.	Mean Gauge.	Mean Interval.	Reductions to 25°.	Reductions to a Vacuum.	Vibrations per diem.
	°	in.	m s	m s	h m s	° °	°	in.				
1	25.0	1.30	20 07	20 15	2 20 11	1.26×1.05=1.32	25.0					
13	25.0	1.30	18 40	18 55	4 18 47.5	0.85×1.05=0.89	+ 0.75	1.30	593.04	+0.33	+0.64	86080.67
							25.75					
	Fresh impulse.											
1	24.9	1.30	26 23	26 55	4 26 39	0.35×1.05=0.37	24.8					
13	24.7	1.30	25 51	26 46	6 26 18.5	0.25×1.05=0.26	+ 0.75	1.30	598.29	+0.24	+0.64	86083.16
							25.55					
26	24.7	1.34	35 25	36 35	8 36 00	0.15×1.05=0.16	24.70 + 0.75 = 25.45	1.32	598.58	+0.20	+0.65	86083.27
	Fresh impulse.											
1	24.8	1.34	04 03	04 09	9 04 06	1.37×1.05=1.44	24.90					
16	25.0	1.40	31 41	31 57	11 31 49	0.80×1.05=0.84	+ 0.75	1.37	590.87	+0.29	+0.67	86079.58
							25.65					

Examining these observations, we have

	I.	IV.	II.	III.
Arcs	1.32 to 0.89	1.44 to 0.84	0.37 to 0.26	0.26 to 0.16
Vibrations	86080.67	86079.58	86083.16	86083.27
Correction for the arcs by the formula . .	+1.98	+2.08	+0.16	+0.06
Numbers which should agree if the corrections computed by the formula were a just compensation	86082.15		86083.32	

The inference here is again to the same effect. The multiplier required to produce accordance is 1.61. The corrections and the corrected vibrations then become

	I. & IV.	II. & III.
Corrections	+3.27	+0.18
Corrected vibrations	86083.39	86083.39

For a purpose foreign to the present object, the slider was on this day at 1.75 inch from the middle of the pendulum towards the weight.

The irregular going of the clock (which stopped altogether soon after the fourth series was completed) may have rendered the result of this day's experiments of less value than that of either of the preceding days, in determining the amount of the multiplier. It was not until the 5th of May following, that, the clock being repaired and replaced, I was able to resume the inquiry by the following observations conducted in the same manner as before. The clock was making 86665.0 vibrations, on an average of several days at this period.

No. of Coincid.	Therm.	Gauge.	Times of Disapp.	Times of Reapp.	Times of Coincidence.	Arcs.	Mean Temp.	Mean Gauge.	Mean Interval.	Reductions to 58°.	Reductions to a Vacuum.	Vibrations per diem.
	°	in.	m s	m s	h m s	° °	°	in.				
1	....	....	53 31	53 33	2 53 32							
2	56.5	2.1	58 21	58 25	2 58 23	1.36 × 1.05 = 1.43	56.60					
3	....	....	03 13	03 15	3 03 14		+ 0.75					
20	....	....	25 39	25 43	4 25 41			2.10	291.035	−0.29	+0.96	86065.61
21	56.7	2.1	30 31	30 35	4 30 33	0.93 × 1.05 = 0.98	57.35					
22	....	....	35 23	35 25	4 35 24							
	Fresh impulse.											
1	57.0	....	47 36	47 43	4 47 39.5							
2	....	2.1	52 29	52 35	4 52 32	0.24 × 1.05 = 0.26	57.32					
3	57.1	....	57 21	57 27	4 57 24		+ 0.75					
21	57.6	....	25 06	25 13	6 25 09.5			2.10	292.46	+0.03	+0.96	86068.85
22	....	2.1	30 56	31 05	6 30 00.5	0.18 × 1.05 = 0.19	58.07					
23	57.6	....	34 49	34 57	6 34 53							

Examining these observations, we have	I.	II.
Arcs	1.43 to 0.98	0.26 to 0.19
Vibrations	86065.61	86068.85
Correction for the arcs by the formula	+2.35	+0.08
Numbers which should agree if the corrections computed by the formula were a just compensation	86067.96	86068.93

The inference is the same as on the former occasions. The multiplier is in this instance 1.42, and the corrections and corrected vibrations become

Corrections	+3.34	+0.11
	86065.61	86068.85
Corrected vibrations	86068.95	86068.96

If now we collect in one view the different multipliers which have been found from these four series of experiments, we have January 27, 1.36; January 29, 1.32; February 3, 1.61; May 5, 1.42: of which four results, that of February 3rd (1.61), from the unfavourable circumstances of the experiments in the irregular going of the clock already noticed, is least entitled to confidence. The arithmetical mean of the four is 1.43; and that of the three, omitting the result of February 3rd, is 1.37. If then we take 1.4 as

the multiplier, to be employed in computing the compensations for the arcs in the experiments with the weight above, to be hereafter related, we may infer with probability that we employ a more correct multiplier than either 1.3 or 1.5. Now, if either of those numbers were substituted for 1.4, the effect would be to alter the rate of the pendulum with the weight above, as deduced from the experiments in the succeeding pages, one tenth of a vibration per diem. To correct the influence of this tenth of a vibration on the convertibility (the object for which the pendulum is vibrated with the weight above), the slider would require to be moved a certain quantity, which would alter the final deduction of the rate, due to the distance between the axes of suspension, less than one hundredth of a second per diem. In employing 1.4 therefore as a multiplier, any uncertainty in the final result, arising from this cause, is limited in all probability to less than .01 of a second per diem.

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§ 2. Weight below.

On the 31st of January and 1st of February 1830, I made the following observations, for the purpose of ascertaining the compensation for the arcs when the weight was below. The clock, by DENT, was making 86313.3 vibrations. The clock had been stopped on the 30th of January, and was stopped again on the 1st of February, to alter its pendulum. The rate was assigned by comparison with the transit clock during the two days it was going.

No. of Coincid.	Therm.	Gauge.	Times of Disapp.	Times of Reapp.	Times of Coincidence.	Arcs.	Mean Temp.	Mean Gauge.	Mean Interval.	Reductions to 30°.	Reductions to a Vacuum.	Vibrations per diem.
	°	in.	m s	m s	h m s	° °	°	in.				
1	....	....	16 00	16 35	9 16 17.5	0.40 × 1.05 = 0.42	29.9					
2	30.3	1.20	28 19	28 55	9 28 37		+ 0.75	1.25	739.8	+0.29	+0.52	86080.77
21	29.5	1.30	22 25	23 18	1 22 51.5	0.23 × 1.05 = 0.24	30.65					
22	....	....	34 49	35 41	1 35 15							
	Fresh impulse.											
1	29.5	1.30	49 28	49 36	1 49 32	1.25 × 1.05 = 1.31	28.75					
39	28.0	1.40	36 18	36 48	9 36 33	0.50 × 1.05 = 0.52	+ 0.75	1.35	737.4	−0.22	+0.56	86079.54
							29.50					
88	28.4	1.52	41 48	43 26	19 42 37	0.14 × 1.05 = 0.15	28.20 + 0.75 = 28.95	1.46	742.12	−0.46	+0.61	86080.81

Examining these observations, we have

	I.	II.	III.
Arcs	0.42 to 0.24	1.31 to 0.52	0.52 to 0.15
Vibrations	86080.77	86079.54	86080.81
Correction for the arcs by the formula	+0.18	+1.29	+0.17
Numbers which should agree if the corrections computed by the formula were just compensations	86080.95	86079.83	86080.98

On the 28th of April following, I repeated the experiment in arcs designed to make the differences between the experimental and computed results still more apparent. The clock, by DENT, was making 86660.5 vibrations on an average of several days about that period.

No. of Coincid.	Therm.	Gauge.	Times of Disapp.	Times of Reapp.	Times of Coincidence.	Arcs.	Mean Temp.	Mean Gauge.	Mean Interval.	Reductions to 58°.	Reductions to a Vacuum.	Vibrations per diem.
	°	in.	m s	m s	h m s	° °	°	in.				
1	53.4	1.60	27 46	27 48	12 27 47	1.42×1.05=1.49	53.70					
13	54.0	1.61	26 05	26 07	1 26 06	1.25×1.05=1.31	+ 0.75	1.605	291.58	−1.56	+0.65	86065.17
							54.45					
26	55.4	1.62	29 18	29 21	2 29 19.5	1.07×1.05=1.12	54.7 + 0.75 = 55.45	1.615	291.81	−1.12	+0.67	86066.09
	Fresh impulse.											
1	56.0	1.62	51 49	51 52	2 51 51.5	0.38×1.05=0.40	56.2					
15	56.4	1.62	00 07	00 11	4 00 09	0.31×1.05=0.33	+ 0.75	1.62	292.68	−0.46	+0.67	86068.53
							56.95					
25	56.2	1.63	48 55	49 00	4 48 57.5	0.28×1.05=0.30	56.3 + 0.75 = 57.05	1.625	292.85	−0.42	+0.68	86068.92
	Fresh impulse.											
1	56.2	1.63	56 49	56 51	4 56 50	1.30×1.05=1.36	56.3					
15	56.4	1.64	04 49	04 52	6 04 50.5	1.12×1.05=1.17	+ 0.75	1.635	291.46	−0.42	+0.68	86066.10
							57.05					

Examining these observations, we have

	I.	II.	III.	IV.	V.
Arcs	1°.49 to 1°.31	1°.31 to 1°.12	0°.40 to 0°.33	0°.33 to 0°.30	1°.36 to 1°.17
Vibrations	86065.17	86066.09	86068.53	86068.92	86066.10
Correction for the arcs by the formula . . .	+3.13	+2·42	+0.22	+0.16	+2.73
Numbers which should agree if the corrections computed by the formula were just compensations	86068.30	86068.51	86068.75	86069.08	86068.83

In both these series of experiments the same indication is afforded, viz. that the retardation of the vibration is greater in large arcs than is covered by the correction computed by the formula. The difference, however, between the results in large arcs and in small arcs, with the computed corrections applied, is much less than takes place when the pendulum is vibrated with the weight above. With the weight below, the computed corrections being multiplied by 1.13, the results are rendered accordant with each other on both days of experiment, and the vibrations become as follows:—

January 31st, large arcs, Exp. II. 86080.99; small arcs, Exp. I. & III. 86081.00.
April 28th, large arcs, Exp. I. II. & V. 86068.92; small arcs, Exp. III. & IV. 86068.94.

The alteration produced by the employment of this multiplier, in the final deduction of the rate of the pendulum from the experiments to be subsequently narrated, is an addition of 0.12 vibration per diem to the number of vibrations which would otherwise have been derived. I should have been glad to have employed a greater number of observations in the more assured determination of this multiplier, but circumstances did not permit me to pursue the inquiry further; and I have only now to refer to the consistency and concurrent indication of those results that were obtained, as an evidence that the multiplier derived from them is in all probability very near the truth. I may also notice, that a change of one unit in the second figure of decimals of this multiplier, would produce an alteration of something less than one hundredth of a second per diem in the rate of the pendulum, derived from the experiments which form the subject of this paper.

It was my intention to have investigated experimentally the cause of the retardation being greater in large arcs than accords with the formula of reduction

to infinitely small arcs; but circumstances not permitting me to do so at present, I have only to state my conjecture, that it is caused by the gliding of the knife edges on the planes, a consequence of the elasticity of the planes. It has been found by M. BESSEL, that small movements of this kind always took place in a pendulum vibrating on a knife edge, whatever might be the nature of the supporting planes; that its direction was the same as the motion of the pendulum,—to the right when the pendulum moved to the right, and vice versâ; and that its amount was proportioned to the arcs of vibration. Supposing that the cause is as I have conjectured, it would have been satisfactory to have measured the amount of the gliding corresponding to particular arcs, *directly*, in the manner that M. BESSEL has done, and to have compared the correction of the *length*, which is the mode of compensation adopted by M. BESSEL, with the correction of the *rate*, which is the method that has been adopted here; by either mode the experiments ought to give the same length for the seconds pendulum.

In discussing the correction for the arcs of vibration, it has appeared the most satisfactory course, to introduce the detail of the experiments relating to that branch of the subject into the body of the discussion itself. In the remainder of the paper I shall pursue the more usual course, of placing together, at the close, the detail of all the experiments, in the order and succession in which they were made; introducing into the discussion, abstracts and results, with proper references to the part of the paper containing the details.

Before we enter on the examination of the rate of the pendulum, it is necessary to ascertain the reduction to a vacuum for the small residue of air which cannot be pumped out of the apparatus, as well as for the small additional quantity which occasionally leaks in. I proceed to collect in one view the results of the experiments which were made at suitable opportunities to determine the amount of this reduction.

Reduction to a Vacuum.

§ 1. Weight above.

The plan of experiment was to compare the vibrations made in full atmospheric pressure, with those in the exhausted apparatus, in circumstances in

other respects as nearly similar as possible. By this comparison, the correction for nearly the full atmospheric pressure is ascertained; the proportional part of which is taken as the equivalent for the small residue of air which cannot be wholly withdrawn, and for the occasional small leakage of the apparatus during the experiments; the pressure withinside the glasses being duly observed and registered by means of a syphon gauge placed by the pendulum. In regarding the correction for the last remaining inch of pressure as a proportional part, namely the thirtieth, of the correction for the whole atmosphere, I refer to the experiments related in a former paper in the Philosophical Transactions, in which it was shown that the corrections for a half atmosphere, and for a quarter atmosphere, bore corresponding proportions to the correction for the full atmosphere.

The following is an abstract of two series of such experiments with the weight above.

	Reference to the details at the close of the paper.	Therm.	Vibrations.	Reduction to mean temp. 57°.	Vibrations at 57°.	Barom. or Gauge.
		°		°		inch.
In the free air .	E	57.5	86056.88	+0.22	86057.10	29.650
	G	59.6	86055.82	+1.14	86056.96 } 86057.03	29.217 } 29.433
Air withdrawn .	F	59.8	86068.56	+1.23	86069.79	1.045
(Slider at 1.5)			Differences		12.76	28.388

		°		°		inch.
In the free air .	O	56.05	86055.95	−0.41	86055.54	29.376
Air withdrawn .	P to S (mean)	56.87	86068.48	−0.06	86068.42	1.572
(Slider at 1.633)			Differences		12.80	27.804

We have then, from these two series, the following differences:

12.76 vibr. corresponding to 28.388 in. of air at 58°.5; or 13.48 vibr. to 30 in.
12.88 —— —— 27.804 —— at 56.1; or 13.89. ——

Whence we obtain the reduction, when the weight is above, in the proportion of 13.68 vibrations per diem for 30 inches of air at 57°.3.

§ 2. Weight below.

Abstract of three series of experiments from which the reduction to a vacuum is derived for the vibrations of the pendulum with the weight below.

	Reference to the details.	Temp.	Vibrations.	Reduction to mean temp. 57°.	Vibrations at 57°.		Barom. or Gauge.	
							inch.	
In free air	A	56°.95	86057.30	−0.02	86057.28		29.727	
	B	57.60	86056.88	+0.26	86057.14	86057.25	29.756	29.740
	D	56.70	86057.48	−0.13	86057.35		29.737	
Air withdrawn .	C	56.95	86068.28	−0.02		86068.24		1.950
(Slider at 1.5)			Differences			10.99		27.790

In free air	N	57°.50	86056.84	+0.22	86057.06	29.457
Air withdrawn .	H to M	56.87	86068.67	−0.06	86068.61	1.211
(Slider at 1.633)			Differences		11.55	28.246

In free air	FF	57°.50	86056.88	+0.22	86057.10	86057.04	29.361	29.349
	GG	58.00	86056.53	+0.44	86056.97		29.337	
Air withdrawn .	W to EE	56.75	86068.71	−0.11		86068.60		0.976
(Slider at 1.566)			Differences			11.56		28.373

From these three series we have the following differences; viz.

10.99 vibr. corresponding to 27.790 in. of air at 57°.1; or 11.86 vibr. to 30 in.

11.55 —— —— 28.246 —— at 57.5; or 12.26 ——

11.56 —— —— 28.373 —— at 57.7; or 12.22 ——

Whence we obtain the reduction when the weight is below, in the proportion of 12.10 vibrations per diem for 30 inches of air at 57°.4.

The mean pressure within the glasses during the fourteen experiments with the weight below, (from which, as will be seen hereafter, the rate of the pendulum was finally derived,) was 1.07 inch: the reduction for which, according to the proportion found above, is 0.43 of a vibration per diem. This amount would be altered only one hundredth of a vibration, were the partial result most distant from the mean substituted for the mean of the three results by which the reduction was determined.

Abstract of the Experiments for the Rate of the Pendulum.

Reference.	Gauge.	Temp.	Duration of experiments.	Vibrations.	Correction to M. T. 57°.	Reduction to a Vacuum.	Corrected Vibrations at 57° in a vacuum.
	inches.	°	h m s				
I. Slider at 1.633. *a.* Weight below.							
H	1.207	57.37	13 58 29	86068.49	+0.16	+0.48	86069.13
I	0.930	56.61	9 17 09.5	86069.04	−0.17	+0.37	86069.24
K	1.365	56.25	14 35 26.5	86068.80	−0.33	+0.55	86069.02
L	0.938	56.67	8 48 33	86069.01	−0.14	+0.37	86069.24
M	1.615	57.47	14 05 25	86067.99	+0.21	+0.65	86068.85
	1.211	56.87	60 15 03	86068.67	−0.06	+0.48	86069.10
I. Slider at 1.633. *b.* Weight above.							
P	1.442	56.70	4 55 48	86068.67	−0.13	+0.66	86069.20
Q	1.650	56.70	4 41 01	86068.45	−0.13	+0.75	86069.07
R	1.685	56.55	8 32 43.5	86068.45	−0.20	+0.76	86069.01
S	1.512	57.55	6 15 10	86068.34	+0.24	+0.69	86069.27
	1.572	56.87	24 24 42.5	86068.48	−0.06	+0.72	86069.14
II. Slider at 1.566. *b.* Weight above.							
T	1.222	58.00	5 46 36.5	86068.76	+0.44	+0.56	86069.76
U	1.460	57.00	9 45 39	86068.83	0.00	+0.67	86069.50
V	1.115	56.60	6 44 40	86069.24	−0.17	+0.51	86069.58
	1.266	57.20	22 16 55.5	86068.94	+0.09	+0.58	86069.61
II. Slider at 1.566. *a.* Weight below.							
W	0.950	56.85	15 03 24	86068.72	−0.07	+0.38	86069.03
X	1.055	56.40	13 01 03	86068.78	−0.26	+0.42	86068.94
Y	1.165	56.50	13 01 05.8	86068.82	−0.22	+0.46	86069.06
Z	0.985	56.95	10 21 25.7	86068.70	−0.02	+0.39	86069.07
A A	0.900	57.30	15 46 32	86068.56	+0.13	+0.36	86069.05
B B	0.895	57.60	9 01 09.5	86068.41	+0.26	+0.36	86069.03
C C	0.920	56.80	9 30 48.5	86068.67	−0.09	+0.37	86068.95
D D	1.070	56.50	9 23 49	86068.97	−0.22	+0.42	86069.17
E E	1.030	56.50	17 36 24	86068.89	−0.22	+0.42	86069.09
	1.000	56.82	112 45 41.5	86068.72	−0.08	+0.40	86069.04

The letters of reference in the first column are to the detail of the experiments at the close of the paper.

If, now, we take a mean of the results in both positions of the pendulum *a* and *b*, and in both positions of the slider I. & II., we have 86069.38 vibrations with the weight above, and 86069.07 vibrations with the weight below, corresponding to the slider at 1.6 inch (being the mean between 1.633 and 1.566) from the middle of the pendulum towards the weight.

The vibrations with the weight above are in excess 0.31 of a vibration. To ascertain the fraction of the tenth of an inch which it would be necessary to move the slider in order to produce perfect convertibility, and the effect of such change in the position of the slider, upon the vibrations with the weight below, we have from the experiments the following data (the letters referring as before to the detail of the experiments at the close of the paper).

Weight above.

		Vibrations.	
Slider at 1.5	E to G	86070.26	making a difference of 1.12 vibration per diem corresponding to 0.133 inch of the slider.
——— 1.566	T to V	86069.61	
——— 1.633	P to S	86069.14	

Weight below.

		Vibrations.	
Slider at 1.5	A to D	86069.00	making a difference of 0.10 vibration per diem corresponding to 0.133 inch of the slider.
——— 1.566	W to E E	86069.04	
——— 1.633	H to M	86069.10	

Whence we obtain by proportion 1.637 as the position of the slider which renders the pendulum perfectly convertible: and the vibrations, in the position of perfect convertibility, 86069.09 with the weight above, and 86069.10 with the weight below;—a result which, it will be seen, is in the closest accordance with the experiments H to S, during which the slider was at 1.633.

Expansion of the Pendulum.

The rate of the pendulum having thus been found for the temperature of 57°, we have to seek its rate at 62°, being the temperature at which Captain Kater referred the distance between the knife edges to Sir George Shuckburgh's scale. To obtain the alteration of rate corresponding to each degree of Fahrenheit from the data furnished by the experiments, we have the rate with the weight below, observed on the 31st of January and 1st of February

at 30°, pp. 467 and 469, to compare with the rate at 57° which has been deduced as above from the experiments in the preceding August and September. The position of the slider in the winter experiments was at 1.6; consequently the result is strictly comparable with the mean of the two results H to M, and W to EE, made in summer, in one of which series the slider was at 1.633, and in the other at 1.566, the mean of which is 1.6. But in fact a small change of position of the slider when the weight is below, has so little influence on the rate, that had there been even a slight difference it might have been safely disregarded for the purpose now in view.

Winter experiments . . .	86081.00	vibrations at	30°
Summer experiments . . .	86069.07	———	57
Differences . . .	11.93	———	27

Equivalent to 0.441 for each degree of FAHRENHEIT.

In the Phil. Trans. for 1830, Art. XIX. I have reported the results of a similar comparison of the rates of an invariable pendulum, made also of plate brass, in winter and in summer; by which it was shown that a degree of FAHRENHEIT corresponded to a change of 0.44 in the rate of that pendulum also. These two results are strongly confirmatory of each other.

It results, then, that the vibrations of Captain KATER's pendulum, which at 57° have been found 86069.10, are 86066.90 at 62°. The distance between the knife edges as measured by Captain KATER is 39.44085 inches of Sir GEORGE SHUCKBURGH's scale, the pendulum and scale being at 62°. The vibrations in a vacuum corresponding to this distance are 86066.90, the temperature of the pendulum being 62°. We have then for the seconds pendulum in the Royal Observatory, at 62° and in a vacuum,

$$\text{In } 86066.90^{2} : 39.44085^{\text{In.}} : : 86400^{2} : 39.13734^{\text{In.}}.$$

Stability of the support of the Pendulum in the preceding experiments.

Being desirous of assuring myself of the stability of the support of the pendulum in the vacuum apparatus, I undertook a distinct series of experiments to obtain the rate of the pendulum on the iron frame, which is permanently affixed to the south wall of the pendulum room in the Royal Observatory, and designed for the use of observers with invariable pendulums, who wish to obtain a basis for their experiments on the variation of gravity at other stations. With this intention, I transferred the agate planes, which had been employed in the experiments in the vacuum apparatus, to the iron frame; and placed the pendulum on them, with the weight below, and the slider at 1.6 inch, making the observations H H to R R as detailed at the close of this paper. The experiments were necessarily made in the free air of the apartment, and are reduced to a vacuum by the reduction already found for the pendulum with the weight below. The rate of the clock, by GRAHAM, which is attached to the wall of the room beneath the iron frame, was furnished me by Mr. THOMAS GLANVILLE TAYLOR, in a memorandum which is subjoined to the detail of the observations. By a mean of the ten experiments H H to R R on the iron frame, the pendulum was found to make 86070.98 vibrations at 53° reduced to a vacuum. The equivalent at 57° is 86069.20, which differs by only 0.10 of a vibration per diem from 86069.10, the rate ascertained in the vacuum apparatus. The rate on the iron frame was obtained by thirty-three hours' vibration of the pendulum; that in the vacuum apparatus by 173 hours. So near an approximation, obtained in less than one fifth of the time that the experiments in the vacuum apparatus were continued, satisfied me that no permanent cause of difference existed, and that it only required that the experiments on the iron frame should be persevered in for the same length of time as those were in the vacuum apparatus, to produce the closest accordance. We may regard therefore the result of the experiments H H to R R, as establishing the equal stability of both supports; and as affording a fair inference that both supports are perfectly stable.

Detail of the Experiments referred to in this paper.

Preliminary Experiments to adjust the Slider, and to obtain the reduction to a vacuum for portions of air remaining in the Apparatus.—The registered arcs must be multiplied by 1.05 throughout, to give the true arcs.

Slider at 1.5 in. from the middle of the pendulum towards the weight. Weight below.

Exp. A. In full atmospheric pressure. Aug. 21, 1829 A.M. to P.M. Dent making 86465.92 vibr.

Barom. { beginning 29.766 / ending .. 29.796 } 29.781 at 57°; +.019 Capill.; −.073 to 32° = 29.727.

No. of Coincid.	Therm.	Gauge.	Times of Disap.	Times of Reap.	Times of Coincidence.	Arcs.	Mean Temp.	Mean Interval.	Mean Gauge.	Correction for Arc.	Vibrations in 24 hours.
	°		m s	m s	h m s	°	°			°	
1	56.7	....	50 42	50 58	9 50 50	0.65	56.95	422.95	....	+0.26	86057.30
33	57.2	....	35 57	36 52	1 36 24.5	0.13					

Exp. B. In full atmospheric pressure. Aug. 21 P.M. Dent making 86465.92 vibrations.

Barom. { beginning 29.796 / ending .. 29.830 } 29.813 at 58°; +.019 Capill.; −.076 to 32° = 29.756.

	°		m s	m s	h m s	°	°			°	
1	....	....	49 59	50 18							
2	57.6	....	57 02	57 19	1 57 10.33	0.62					
3	....	....	04 02	04 22							
25	....	....	38 49	39 28			57.6	422.52	....	+0.28	86056.88
26	57.6	....	45 51	46 30	4 46 10.83	0.18					
27	....	....	52 53	53 54							

Exp. C. In rarified air. Aug. 21 P.M. to Aug. 22 A.M. Dent making 86465.92 vibrations.

	°	in.	m s	m s	h m s	°	°			°	
1	....	....	25 53	26 03							
2	57.4	1.00	33 05	33 16	5 36 47.25	1.15					
3	....	....	40 18	40 30			56.2				
4	....	....	47 30	47 43			+ 0.75	434.17	1.95	+0.68	86068.26
122	....	....	01 11	01 46			56.95				
123	....	....	08 25	09 05							
124	55.0	2.90	15 40	16 20	20 12 22	0.16					
125	....	....	22 53	23 36							

Exp. D. In full atmospheric pressure. Aug. 22 A.M. Dent making 86465.92 vibrations.

Barom. { beginning 29.816 / ending .. 29.760 } 29.788 at 55°5 ; +.019 Capill. ; —.070 to 32° =29.737.

No. of Coincid.	Therm.	Gauge.	Times of Disap.	Times of Reap.	Times of Coincidences.	Arcs.	Mean Temp.	Mean Interval.	Mean Gauge.	Correction for Arc.	Vibrations in 24 hours.
	°		m s	m s	h m s	°	°			°	
1	56.5	....	03 41	03 53	9 03 47	1.00	56.7	422.71	....	+0.67	86057.48
26	....	....	59 43	00 07							
27	56.9	....	06 44	07 10	12 06 57.33	0.23					
28	....	....	13 46	14 14							

Pendulum removed. Planes examined. Pendulum replaced, Weight above.

Exp. E. In full atmospheric pressure. Aug. 22 P.M. Dent making 86465.92 vibrations.

Barom. { beginning 29.760 / ending .. 29.650 } 29.705 at 57°.5 ; +.019 Capill. ; .074 to 32° = 29.650.

	°		m s	m s	h m s	°	°			°	
1	....	....	33 50	34 00							
2	57.5	....	40 49	41 00	12 40 54.5	1.03					
3	....	....	47 48	48 00							
26	....	....	29 00	30 13			57.5	421.78	....	+0.99	86056.88
27	....	....	35 56	37 12							
28	57.5	....	43 04	44 20	3 43 40.7	0.095					
29	....	....	50 02	51 26							
30	....	....	57 04	58 30							

Exp. F. In rarified air. Aug. 23 A.M. to P.M. Dent making 86465.92 vibrations.

	°	in.	m s	m s	h m s	°	° 59.05 + 0.75 = 59.80			°	
1	58.3	0.94	18 40	18 50	9 18 45	1.24		433.85	1.045	+1.27	86068.56
66	59.8	1.15	08 30	09 01	5 08 45.5	0.30					

Exp. G. In full atmospheric pressure. Aug. 24 A.M. Dent making 86466.00 vibrations.

Barom. { beginning 29.200 / ending .. 29.360 } 29.280 at 60° ; +.019 Capill. ; —.082 to 32° = 29.217.

	°		m s	m s	h m s	°	°			°	
1	59.8	....	4 32	4 42	8 4 37	1.19	59.6	420.52	....	+1.06	86055.82
26	59.4	....	59 24	00 16	10 59 50	0.12					

The ends of the bar of the pendulum were then blackened with lamp-black and varnish, to make a stronger contrast with the white disc on the clock pen-

dulum. The slider was moved to 1.633 inch from the middle of the pendulum towards the weight. The pendulum was then replaced, and the experiments were commenced for determining the rate due to the distance between the axes of suspension.

Slider at 1.633 inch from the middle towards the weight. Weight below.

EXP. H. August 24 P.M. to August 25 A.M. DENT making 86466.29 vibrations.

No. of Coincid.	Therm.	Gauge.	Times of Disap.	Times of Reap.	Times of Coincidences.	Arcs.	Mean Temp.	Mean Interval.	Mean Gauge.	Correction for Arc.	Vibrations in 24 hours.
	°	in.	m s	m s	h m s	°	°			°	
1	58.45	0.965	42 57	43 07	5 43 02	1.24	56.62	433.70	1.207	+0.95	86068.49
117	54.8	1.450	41 16	41 46	19 41 31	0.26	+ 0.75				
							57.37				

EXP. I. August 25 A.M. to August 25 P.M. DENT making 86466.31 vibrations.

	°	in.	m s	m s	h m s	°	°			°	
1	55.0	0.76	09 53	10 04	20 09 58.5	1.08	55.86	434.15	0.930	+1.05	86069.04
	55.4	....	....	....	22 0 0	....	+ 0.75				
	56.0	....	....	....	24 0 0	....					
	56.4	....	....	....	2 0 0	....	56.61				
78	56.5	1.10	26 56	27 20	5 27 08	0.42					

EXP. K. August 25th P.M. to August 26th A.M. DENT making 86466.33 vibrations.

	°	in.	m s	m s	h m s	°	°			°	
1	56.6	1.10	32 23	32 34	5 32 28.5	1.22	55.50	434.10	1.365	+0.85	86068.80
122	54.4	1.63	07 39	08 11	20 07 55	0.21	+ 0.75				
							56.25				

EXP. L. August 26th A.M. to August 26th P.M. DENT making 86466.15 vibrations.

	°	in.	m s	m s	h m s	°	°			°	
1	....	....	32 02	32 14							
2	55.0	0.685	....	....	20 39 22	0.99					
3	....	....	46 30	46 42			55.92				
	55.8	....	....	....	23 45 0		0.75	434.42	0.938	+0.93	86069.01
	56.4	....	....	....	2 45 0						
74	....	....	20 29	20 52			56.67				
75	56.5	1.190	27 43	27 06	5 27 55	0.40					
76	....	....	34 58	35 22							

Exp. M. August 26th P.M. to August 27th A.M. Dent making 86465.98 vibrations.

No. of Coincid.	Therm.	Gauge.	Times of Disap.	Times of Reap.	Times of Coincidences.	Arcs.	Mean Therm.	Mean Interval.	Mean Gauge.	Correction for Arc.	Vibrations in 24 hours.
	°	in.	m s	m s	h m s	°	°			°	
1	56.7	1.24	51 10	51 19	5 51 14.5	1.27	56.73 + 0.75 = 57.48	433.55	1.615	+0.91	86067.99
118	56.75	1.99	56 22	56 57	19 56 39.5	0.21					

Exp. N. August 27th A.M. Dent making 86466.06 vibrations.

Barom. { beginning 29.520 57.5 / ending .. 29.508 58.0 } 29.514 ; +.019 Capill.; −0.76 to 32° = 29.457.

	°		m s	m s	h m s	°	°			°	
1	57.5	....	47 23	47 31	20 47 27	1.17	57.50	421.61	....	+0.95	86056.84
24	....	....	28 51	29 15							
25	57.5	....	....	....	23 36 05.75	0.30					
26	....	....	42 58	43 19							

The Pendulum was then removed; the planes examined, and found truly horizontal; and the Pendulum replaced with the Weight above.

Exp. O. In Atmospheric Pressure. August 28th A.M. Dent making 86466.25 vibrations.

Barom. { beginning 29.382 / ending . 29.470 } 29.426 55°.5 ; +.019 Capill. ; −.069 to 32° =29.376.

No. of Coincid.	Therm.	Gauge.	Times of Disap.	Times of Reap.	Times of Coincidence.	Arc of Vibration.	Mean Therm.	Mean Interval.	Mean Gauge.	Correction for Arc.	Vibrations in 24 hours.
	°		m s	m s	h m s	°	°			°	
1	56.0	....	18 52	19 02	20 18 57	1.20	56.05	420.33	....	+1.11	86055.95
25	56.1	....	06 35	07 35	23 07 05	0.13					

Exp. P. August 28th P.M. Dent making 86466.35 vibrations.

	°	in.	m s	m s	h m s	°	°			°	
1	55.5	0.895	46 52	47 01	00 50 32.25	1.29	55.95 + 0.75 = 56.70	432.88	1.442	+1.82	86068.67
2	55.7	....	54 03	54 13							
42	56.3	....	42 32	42 56	5 46 20.25	0.48					
43	56.3	1.990	49 45	50 08							

Exp. Q. August 28th P.M. Dent making 86466.40 vibrations.

No. of Coincid.	Therm.	Gauge.	Times of Disap.	Times of Reap.	Times of Coincidence.	Arc of Vibration.	Mean Therm.	Mean Interval.	Mean Gauge.	Correction for Arc.	Vibrations in 24 hours.
	°	in.	m s	m s	h m s	°	°			°	
1	56.3	1.13	14 33	14 43	6 14 38	1.38	55.95	432.33	1.650	+2.07	86068.45
40	55.6	2.17	55 24	55 54	10 55 39	0.51	+ 0.75				
							56.70				

Exp. R. August 28th P.M. to August 29th A.M. Dent making 86466.44 vibrations.

	°	in.	m s	m s	h m s	°	°			°	
1	55.6	0.85	9 24	9 37	11 09 30.5	1.32	55.80	433.29	1.685	+1.15	86068.45
72	56.0	2.52	41 51	42 37	19 42 14	0.20	+ 0.75				
							56.55				

Exp. S. August 29th A.M. to August 29th P.M. Dent making 86466.43 vibrations.

	°	in.	m s	m s	h m s	°	°			°	
1	56.0	0.935	3 13	3 35	20 3 24	1.25	56.80	432.89	1.512	+1.40	86068.34
53	57.6	2.09	18 19	18 49	2 18 34	0.34	+ 0.75				
							57.55				

Slider removed to 1.566 &c. from the middle towards the weight. Planes examined, and found horizontal. Pendulum replaced, Weight above.

Exp. T. August 29th P.M. Dent making 86466.40 vibrations.

	°		m s	m s	h m s	°	°			°	
1	58.0	0.985	42 13	42 23	4 42 18	1.20	57.25	433.26	1.222	+1.50	86068.76
49	56.5	1.460	28 37	29 12	10 28 54.5	0.41	+ 0.75				
							58.00				

Exp. U. August 29th P.M. to August 30th A.M. Dent making 86466.39 vibrations.

	°	in.	m s	m s	h m s	°	°			°	
1	56.6	0.960	41 17	41 27	10 41 22	1.32	56.25	433.81	1.460	+1.09	86068.83
82	55.9	1.960	26 35	27 27	20 27 01	0.17	+ 0.75				
							57.00				

Exp. V. August 30th A.M. to August 30th P.M. Dent making 86466.32 vibrations.

No. of Coincid.	Therm.	Gauge.	Times of Disap.	Times of Reap.	Times of Coincidence.	Arc of Vibration.	Mean Therm.	Mean Interval.	Mean Gauge.	Correction for Arc.	Vibrations in 24 hours.
	°	in.	m s	m s	h m s	°	°			°	
1	55.9	1.38	34 39	34 48	20 34 43.5	1.38	55.85	433.57	1.115	+1.78	86069.24
57	55.8	0.40	19 10	19 37	3 19 23.5	0.40	+ 0.75				
							56.60				

Pendulum removed and replaced. Weight below.

Exp. W. August 30th P.M. to August 31st A.M. Dent making 86466.26 vibrations.

	°	in.	m s	m s	h m s	°	°			°	
1	56.7	0.76	52 59	53 06	4 53 02.5	1.43	56.10	433.63	0.95	+1.26	86068.72
126	55.5	1.14	56 12	56 41	19 56 26.5	0.30	+ 0.75				
							56.85				

Exp. X. August 31st A.M. to August 31st P.M. Dent making 86466.26 vibrations.

	°	in.	m s	m s	h m s	°	°			°	
1	55.5	0.78	05 00	05 10	20 05 05	1.22	55.65	433.92	1.055	+1.02	86068.78
109	55.8	1.33	05 49	06 27	9 06 08	0.30	+ 0.75				
							56.40				

Exp. Y. August 31st P.M. to September 1st A.M. Dent making 86466.31 vibrations.

	°	in.	m s	m s	h m s	°	°			°	
1	....	....	23 33	23 45							
2	56.0	0.80	30 44	30 56	9 30 50.33	1.25	55.75	433.94	1.165	+1.03	86068.82
3	....	....	37 56	38 08			+ 0.75				
109	....	....	24 27	24 58							
110	55.5	1.53	31 42	32 10	22 31 56.17	0.29	56.50				
111	....	....	38 55	39 25							

Exp. Z. September 1st A.M. to September 1st P.M. Dent making 86466.29 vibrations.

	°	in.	m s	m s	h m s	°	°			°	
1	55.6	0.82	48 11	48 20	22 51 51	1.26	56.2	433.55	0.985	+1.28	86068.70
2	....	....	55 22	55 32			+ 0.75				
87	....	....	9 26	9 52	9 13 16.75	0.41	56.95				
88	56.8	1.15	16 41	17 08							

Exp. A A. September 1st P.M. to September 2nd P.M. Dent making 86466.24 vibrations.

No. of Coincid.	Therm.	Gauge.	Times of Disap.	Times of Reap.	Times of Coincidence.	Arc of Vibration.	Mean Therm.	Mean Interval.	Mean Gauge.	Correction for Arc.	Vibrations in 24 hours.
	°	in.	m s	m s	h m s	°	°				
1	57.0	0.665	23 35	23 44	9 23 39.5	1.40	56.55				
132	56.1	1.140	9 58	10 25	25 10 11.5	0.30	+ 0.75	433.53	0.90	+1.23	86068.56
							57.30				

Exp. B B. September 2nd P.M. Dent making 86466.24 vibrations.

	°	in.	m s	m s	h m s	°	°				
1	57.0	0.72	15 52	16 01	1 15 56.5	1.30	56.85				
76	56.7	1.07	16 54	17 18	10 17 06	0.55	+ 0.75	432.93	0.895	+1.63	86068.41
							57.60				

Exp. C C. September 2nd P.M. to September 3rd A.M. Dent making 86466.24 vibrations.

	°	in.	m s	m s	h m s	°	°				
1	56.7	0.70	25 49	26 02	10 25 55.5	1.20	56.05				
80	55.4	1.14	56 33	56 55	19 56 44	0.48	+ 0.75	433.53	0.92	+1.33	86068.67
							56.80				

Exp. D D. September 3rd A.M. to September 3rd P.M. Dent making 86466.23 vibrations.

	°	in.	m s	m s	h m s	°	°				
1	55.5	0.80	06 37	06 46	20 06 41.5	1.30	55.75				
79	56.0	1.34	30 17	30 44	5 30 30.5	0.48	+ 0.75	433.70	1.07	+1.47	86068.97
							56.50				

Exp. E E. September 3rd P.M. to September 4th A.M. Dent making 86466.23 vibrations.

	°	in.	m s	m s	h m s	°	°				
1	56.0	0.89	40 31	40 40	5 40 35.5	1.30	55.75				
147	55.5	1.17	16 42	17 17	23 16 59.5	0.19	+ 0.75	434.14	1.03	+0.99	86068.89
							56.50				

The air was then admitted, and the following observations made to obtain the reduction to a vacuum, for the small portion of air remaining in the apparatus, indicated by the gauge, in those of the preceding experiments in which the weight was below.

Slider at 1.566. Weight below.

Exp. F F. September 7th A.M. to September 7th P.M. Dent making 86465.83 vibrations.

Barom. { beginning 29.422 57.5 / ending . 29.420 60 } 29.421 59°; + .019 Capill.; −.079 reduction to 32° = 29.361.

No. of Coincid.	Therm.	Gauge.	Times of Disap.	Times of Reap.	Times of Coincidence.	Arc of Vibration.	Mean Therm.	Mean Interval.	Mean Gauge.	Correction for Arc.	Vibrations in 24 hours.
	°		m s	m s	h m s	°	°			°	
1	57.0	....	09 05	09 13	10 09 09	1.22	57.5	422.00	....	+0.85	86056.88
31	58.0	....	39 54	40 24	1 40 09	0.21					

Exp. G G. September 7th P.M. Dent making 86465.80 vibrations.

Barom. { beginning 29.420 60 / ending . 29.382 60 } 29.401 60°; + .019 Capill.; − .083 reduction to 32° = 29.337.

	°		m s	m s	h m s	°	°			°	
1	58.0	....	50 37	50 47	1 50 42	1.18	58.0	421.73	....	+0.79	86056.53
31	58.0	....	21 18	21 50	5 21 34	0.20					

Mr. Taylor's *memorandum of the computation of the rate of the Clock by* Dent.

The clock's rate in these experiments has been deduced from daily comparisons between it and the Greenwich transit clock; the daily rate of the latter being determined from the observations of several stars and of the sun. With reference to these observations, it may be necessary to remark that they are made by three several observers, as is sufficiently shown in the Greenwich observations by the initials of each observer's name; and in making use of these for determining right ascensions, or the rate of the clock, it becomes necessary to apply to each observed transit the constant difference which is found to exist between the observer, and the observer of the same star on the following day, with which it is compared: for this purpose I have employed the difference as pointed out by a great many observations made for the express purpose; whence it appears that if the observer T. noted the passage of a star at the time τ, the observers T. T. and N. would observe it to pass at $\tau + 0^s.16$ and $\tau + 0^s.35$ respectively. Making use of these, the rate of the Greenwich transit clock comes out:

1829.	s
August 21 to 24	−0.36
——— 25	−0.22
——— 26	−0.18
——— 27	−0.42
——— 28	−0.25
——— 29	−0.34
——— 30	−0.15
——— 31	−0.24

	s
September 1	−0.24
——— 3	−0.32
——— 4	−0.20
——— 6	−0.38
——— 7	−0.31
——— 8	−0.11
Mean .	−0.266

From the near accordance of these results with one another, and from a consideration of the inability of two or three observations (which could only be taken in some cases, on account of the cloudy weather) to determine very correctly the rate, I have preferred taking the general mean $0^s.27$ rather than each individual result. This was accordingly employed with the following comparisons.

Comparison of the Clock DENT *with the Greenwich Transit Clock.*

1829.	DENT. d	h	m	Transit Clock. h	m	s	Daily rate of DENT. m	s	Rates employed. m	s	
August	20	21	52	7	51	50.44					
———	24	5	24	15	33	13.45	+1	5.92	+1	5.92	Aug. 23
———	24	22	9	8	20	11.95	1	6.66	1	6.29	— 24
———	25	22	37	8	51	5.40	1	6.01	1	6.33	— 25
———	26	23	16	9	33	0.20	1	5.96	1	5.98	— 26
———	27	23	40	9	59	52.88	1	6.32	1	6.14	— 27
———	28	23	11	9	33	39.00	1	6.60	1	6.46	— 28
———	29	22	28	8	53	23.90	1	6.18	1	6.39	— 29
———	30	23	6	9	34	18.20	1	6.34	1	6.26	— 30
Sept.	1	0	3	10	34	14.80	1	6.28	1	6.31	— 31
———	2	0	8	10	42	5.30	1	6.19	1	6.24	Sept. 1
———	3	23	28	10	7	40.33	1	6.28	1	6.23	— 2 & 3
———	6	0	0	10	45	24.00	1	6.19	1	6.23	— 4 & 5
Clock was stopped for the re-adjustment of the disc.											
———	7	2	41	13	30	44.20	1	6.09	1	6.14	— 7
———	8	2	59	13	51	36.40			1	6.14	— 8

The column entitled 'Rates employed' will be found to be the mean between the two daily rates in the preceding column; these are those which the clock may be supposed to have attained at midnight, the middle time between the two comparisons; but since the comparisons were taken in the middle of

the day, with observations of coincidences before and after, it will be advisable to take the mean of these daily rates as above for the rate to be employed throughout on any one day, rather than employ the former for coincidences observed in the morning, and the latter for afternoon coincidences.

(Signed) THOMAS GLANVILLE TAYLOR.

Experiments with Captain KATER's Pendulum on the fixed iron frame on the south wall of the Pendulum Room at the Royal Observatory. The agate planes the same which had been used in the vacuum apparatus. The same thermometer also, and arc. Barometer, the standard of the Observatory. Slider at 1.6. Weight below. Clock by GRAHAM; its rate furnished by Mr. THOMAS GLANVILLE TAYLOR in the subjoined memorandum. The correction for the arcs computed by the usual formula, and multiplied by 1.13. (p. 469.)

EXP. H H. September 30. GRAHAM making 86520.71 vibrations.

Barom. $\left\{\begin{matrix}30.110\ 51\\30.116\ 51\end{matrix}\right\}$ 30.113; +.019 Capill.; −.058 to 32° = 30.074.

No. of Coincid.	Therm.	Times of Disap.	Times of Reap.	Times of Coincidence.	Arcs of Vibration.	Mean Temp.	Mean Interval.	Correction for Arc.	Reduc^{n} to mean temp. 53°	Reduction to a vacuum.	Vibrations in vacuo at 53°.
	°	m s	m s	h m s	°	°		°			
1	....	3 33	3 43								
2	49.65	9 47	9 58	11 09 52.3	0.80 × 1.05 = 0.84	50.5	375.38	+0.43	−1.10	+12.30	86071.35
3	....	16 00	16 13								
30	....	4 49	5 16								
31	51.35	....	....	2 11 18.2	0.19 × 1.05 = 0.20						
32	....	17 20	17 48								

EXP. I I. Fresh impulse. Barom. $\left\{\begin{matrix}30.118\ 51.25\\30.144\ 51.25\end{matrix}\right\}$ 30.131; +.019 Capill.; −.058 to 32° = 30.092.

	°	m s	m s	h m s	°	°		°			
1	51.3	35 47	35 56	2 35 51.5	0.80 × 1.05 = 0.84	51.1	375.02	+0.54	−0.84	+12.30	86071.28
24	50.9	59 24	59 50	4 59 37	0.28 × 1.05 = 0.29						

EXP. K K. October 1. GRAHAM making 86520.71 vibrations.

Barom. $\left\{\begin{matrix}30.150\ 50\\30.152\ 54\end{matrix}\right\}$ 30.151; +.019 Capill.; −.060 to 32° = 30.110.

	°	m s	m s	h m s	°	°		°			
1	50.8	41 33	41 40	9 41 36.5	0.81 × 1.05 = 0.85	51.65	375.10	+0.47	−0.59	+12.28	86071.52
31	52.5	48 57	49 22	0 49 09.5	0.21 × 1.05 = 0.22						

EXP. L L. Fresh impulse. Barom. $\left\{\begin{matrix}30.152\\30.115\end{matrix}\right\}$ 30.133 at 55°; +.019 Capill.; — .069 to 32° = 30.083.

No. of Coincid.	Therm.	Times of Disap.	Times of Reap.	Times of Coincidence.	Arcs of Vibration.	Mean Temp.	Mean Interval.	Correction for Arc.	Reduc^{n} to mean temp.53°	Reduction to a Vacuum.	Vibrations in Vacuums at 53°.
	°	m s	m s	h m s	°						
1	54.8	17 11	17 22	1 17 16.5	0.80×1.05=0.84	53.8	373.91	+0.39	+0.35	+12.21	86070.85
36	52.8	55 15	55 32	4 55 23.5	0.15×1.05=0.16						

EXP. M M. October 3. GRAHAM making 86520.80 vibrations.

Barom. $\left\{\begin{matrix}29.697\\29.650\end{matrix}\right\}$ 29.673 at 57°; +.019 Capill.; — .072 to 32°= 29.620.

	°	m s	m s	h m s	°						
1	55.0	25 36	25 48	10 25 42	0.78×1.05=0.82	54.8	373.39	+0.36	+0.79	+12.02	86070.53
36	54.6	03 23	03 38	2 03 30.5	0.15×1.05=0.16						

EXP. N N. Fresh impulse. Barom. $\left\{\begin{matrix}29.650\\29.648\end{matrix}\right\}$ 29.649 at 56°; +.019 Capill.; —.070 to 32°=29.598.

	°	m s	m s	h m s	°						
1	54.7	8 51	9 01	2 8 56	0.84×1.05=0.88	54.55	373.5	+0.50	+0.68	+12.01	86070.71
30	54.4	9 15	9 40	5 9 27.5	0.22×1.05=0.23						

EXP. O O. October 4. GRAHAM making 86520.89 vibrations.

Barom. $\left\{\begin{matrix}29.860\\29.856\end{matrix}\right\}$ 29.858 at 52°; +.019 Capill.; — .061 to 32° = 29.816.

	°	m s	m s	h m s	°						
1	52.5	01 25	01 34	10 01 29.5	0.82×1.05=0.86	53.1	374.16	+0.39	+0.04	+12.12	86070.97
40	53.7	04 31	04 52	2 04 41.5	0.14×1.05=0.15						

EXP. P P. Fresh impulse. Barom. $\left\{\begin{matrix}29.856\\29.850\end{matrix}\right\}$ 29.853 at 54°; +.019 Capill.; — .066 to 32° = 29.806.

	°	m s	m s	h m s	°						
1	53.7	10 37	10 47	2 10 42	0.77×1.05=0.81	54.0	373.80	+0.49	+0.44	+12.11	86071.03
28	54.3	58 41	59 08	4 58 54.5	0.23×1.05=0.24						

EXP. Q Q. October 5. GRAHAM making 86520.93 vibrations.

Barom. $\left\{\begin{matrix}29.470\\29.472\end{matrix}\right\}$ 29.471 at 55°; +.019 Capill.; — .068 to 32° = 29.422.

	°	m s	m s	h m s	°						
1	54.2	40 43	40 55	10 40 49	0.80×1.05=0.84	54.25	373.73	+0.36	+0.55	+11.93	86070.74
40	54.3	43 35	43 54	2 43 44.5	0.13×1.05=0.14						

Exp. R R. Fresh impulse. Barom. $\left\{\begin{matrix}29.472\\29.500\end{matrix}\right\}$ 29.486 at 53°.5 ; +.019 Capill. ; −.065 to 32°=29.440.

No. of Coincid.	Therm.	Times of Disap.	Times of Reap.	Times of Coincidence.	Arcs of Vibration.	Mean Temp.	Mean Interval.	Correction for Arc.	Reduction to mean temp. 53°	Reduction to a Vacuum.	Vibrations in Vacuum at 53°.
	°	m s	m s	h m s	°	°		°			
1	54.4	50 07	50 17	2 50 12	0.80×1.05=0.84	53.7	373.80	+0.35	+0.30	+11.97	86070.64
43	53.0	11 39	12 04	7 11 51.5	0.12×1.05=0.13						

Mr. Taylor's *memorandum of the computation of the rate of the Clock by* Graham.

The rate of the clock by Graham has been determined by comparisons between it and the Greenwich transit clock, made at intervals of twelve hours nearly; the rate of the latter being determined by transits of the sun and of several stars, from which it appears that the transit clock's rate was,

			s
1829.	September 29 evening	to September 30 evening	+0.06
	——— 30 ———	to October 1 ———	−0.14
	October 1 ———	to ——— 2 ———	−0.04

These being employed with the following comparisons give the rate of the clock Graham:

	Graham. h m	Transit Clock. h m s	Rate of Graham. m s
September 30 morning	18 33	11 35 27.05	+2 0.76
——— 30 evening	6 23	23 26 14.10	2 0.63
October 1 morning	19 20	12 24 26.48	2 0.79
——— 1 evening	6 33	23 38 20.45	2 0.67
——— 2 morning	18 58	12 4 20.30	

The very near accordance of these results with their mean $+2^m\ 0^s.71$, will seem to justify the use of this quantity for the experiments of September 30 and October 1.

Daily rate of clock Graham, October 3 to 6.

			m s
1829.	October 3 noon	to 4 noon	+2 0.80
	——— 4 ———	to 5 ———	2 0.89
	——— 5 ———	to 6 ———	0.93

(Signed) Thomas Glanville Taylor.